A Review on PAPR Reduction Techniques in MIMO OFDM Transmission

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Abstract- Wireless Communication is one of the major aspects of life. The progression in age and its growing demands, there has been rapid development in the field of communication. For better transmission system single carrier waves are being replaced by multi carrier waves techniques as MIMO OFDM is implemented now days. As increasing the demand for high performance wireless is enabled by using the multiple antennas at both base station and users ends. Multiple antenna technology enables high capacity especially for internet and multimedia services it also increases range and reliability. In the Multiple Inputs Multiple Outputs OFDM system, Peak – to Average Power Ratio (PAPR) of these signal have some undesirable effects on the system performance.

In this research paper we have reviewed the various PAPR reduction technologies for achieving the optimum system performance of MIMO OFDM Transmission.

Keywords: MIMO OFDM, IDFT, PAPR, Cyclic Prefix, Amplitude Clipping & Filtering

I. Introduction

OFDM is one of the many multicarrier modulation schemes, which provides high spectral efficiency, low implementation complexity, less susceptibility to echoes and non linear distortion. Owing to these advantages of the OFDM system, it is greatly used in various communication systems. But the main problem one faces for implementing this system is the high peak to average power ratio of this system. A large PAPR increases the difficulty of the analog to digital and digital to analog converter and reduces the efficiency of the radio frequency (RF) power amplifier [3,6]. Regulatory and application constraints can be implemented to reduce the peak transmitted power which in turn reduces the range of multi carrier transmission. This lead to the hindrance of spectral growth and the transmitter power amplifier is no longer confined to linear region in which it must operate. This has a injurious effect on the battery lifetime. Therefore in communication system, it has been observed that all the potential benefits of multi carrier transmission can be out - weighed by a high PAPR value [3].

There are a number of techniques to deal with the problem of PAPR. Some of them are amplitude clipping, clipping and filtering, partial transmit sequence (PTS) and „interleaving". These techniques achieve PAPR reduction at the expense of transmit signal power increase, bit error rate (BER) increase with data rate loss and computational complexity increase [3].

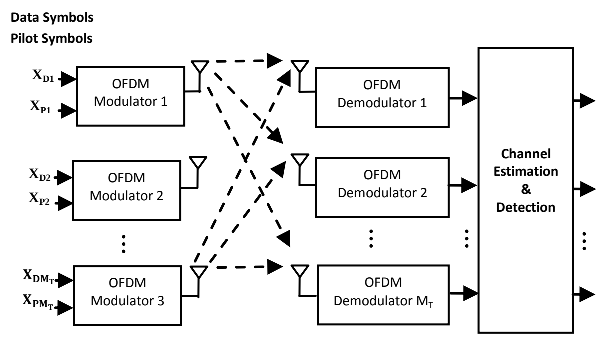

Fig. 1 Shows the MIMO OFDM Transmission System.

Practical communication systems are usually peak power limited. An OFDM signal consists of a large number of independently modulated subcarriers, which on coherent addition may produce a high instantaneous peak with respect to the average signal level. High power amplifiers (HPA's) are used to amplify the time domain OFDM signal to the desired power level. In order to deal with the large fluctuations in the envelope of OFDM signal, HPA's are required to have a large linear range. Such HPA's are costly, bulky and difficult to design. If an HPA with limited linear range is utilized for amplification, it may operate near saturation and can cause out-of-band (OOB) radiations and in-band distortion. The OOB distortion/noise is a major concern, especially in wireless communications, where large differences in signal strength from a mobile transmitter impose stringent requirements on adjacent channel interference (ACI) [48]. To accommodate large envelope fluctuations of the OFDM signal, the digital to analog converter (DAC) and analog to digital converter (ADC) are also required to have a wide dynamic range, which further increases the cost and complexity of the OFDM system. The recent interest in the application of OFDM to present and next generation wireless communication networks has triggered the development of numerous schemes to combat this problem.

In addition to this, OFDM system requires tight frequency synchronization in comparison to single carrier systems, because in OFDM, the subcarriers are narrowband. Therefore, it is sensitive to small frequency offset between the transmitted and the received signal, which may arise due to Doppler Effect in the channel, or due to mismatch between transmitter and receiver local oscillator frequencies. This carrier frequency offset (CFO) disturbs the orthogonality of the subcarriers and the signal on any particular subcarrier will not remain independent of the remaining subcarriers. This phenomenon, known as inter-carrier interference (ICI) [56], is another challenge in the error-free demodulation and detection of OFDM symbols.

II. PEAK-TO-AVERAGE POWER RATIO

Presence of large number of independently modulated sub-carriers in an OFDM system the peak value of the system can be very high as compared to the average of the system. As the ratio of the peak to average power value is termed as Peak-to-Average Power Ratio. Coherent adding together of N signals of same phase produces a peak which is N times the average signal.

The main disadvantages of a high PAPR are as follows:-

1. Increased complexity in the analog to digital and digital to analog converter.

2. Reduction is efficiency of RF amplifiers.

In general, the PAPR of a continuous time baseband OFDM signal x(t) of (2.1) is defined as the ratio of the maximum instantaneous power to its average power [57]

$$PAPR(x(t)) = \frac{max\ 0 \leq t \leq T_s[\ |x(t)\ |^2]}{P_{av}}$$

where P_{av} is the average power and can be computed in frequency domain because IFFT is a unitary transformation.

PAPR of A Multicarrier Signal

Let the data block of length *N* be represented by a vector $X=[X_0, X_1, \ldots, X_{N-1}]^T$. During the symbol X_k in the set *X* is *T* and represents one of the sub-carriers $\{f_n,\ n = 0,1,\ldots,N-1\}$set. As the *N* sub- carriers chosen to transmit the signal are orthogonal to each other, so we can have $fn = n\Delta f$, where $n\Delta f = 1/NT$ and *NT* is the duration of the OFDM data block *X*. Addition with the complex data block for the OFDM signal to be transmitted is given by

$$x(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n . e^{j2\pi n\Delta f t}, 0 \leq t \leq NT,$$

Therefore the PAPR of the transmitted signal is defined as

$$PAPR(x(t)) = \frac{max\ 0 \leq t \leq NT[\ |x(t)\ |^2]}{1/NT \int_0^{NT}\ |x(t)\ |^2\, dt}$$

Reducing the *max* |*x(t)*| is the principle goal of PARP reduction techniques. As, discrete- time signals are dealt with in the majority systems, numerous PAPR techniques are implemented to deal with amplitudes of various samples of *x(t)*. As a result of symbol spaced output in the first equation we find some of the peaks missing which can be compensated by oversampling the equation by some factor to give the true PAPR value.

PAPR Reduction Technique:

PAPR reduction techniques vary according to the needs of the system and are dependent on many factors. PAPR reduction capability, increase in power in transmit signal, data rate decreases, complexity of computation and increase in the bit-error rate at the receiver end are various factors which are taken into account before adopting a PAPR reduction technique of the system. [3]. Many PAPR reduction techniques are proposed in the literature [23]-[39]. Here are some techniques and discuss their advantages and disadvantages in terms of PAPR reduction capability, BER degradation and computational complexity. The PAPR reduction schemes are majorly divided into two categories

a) Distortion Based Techniques.

b) Non-distortion Techniques.

Distortion Based Techniques:

The schemes that introduce spectral re-growth belong to this category. Distortion based techniques are the most straightforward PAPR reduction methods. Furthermore, these techniques distort the spectrum, this spectrum distortion or "spectral re-growth" can be corrected to a certain extent by using filtering operation.

Clipping and Filtering:

Clipping is one of the simplest techniques to reduce the PAPR of OFDM signal. Filter reduces the peak of the OFDM signal by clipping the signal to the desired level. This operation can be implemented on discrete time samples prior to the DAC or by designing the power amplifiers with saturation level lesser than the OFDM signal dynamic range. The amplitude clipper limits the peak of the envelope of the input OFDM signal to a predetermined threshold value (o γ) or otherwise passes the input signal unperturbed. The clipping operation can be mathematically defined as [24]

Selected Mapping

In this a set of sufficiently different data blocks representing the information same as the original data blocks are selected. Variety of data blocks with low PAPR value makes it appropriate for transmission.

Partial Transmit Sequence

Transmitting the only part of data by varying sub-carrier which covers all the information to be sent in the signal as a whole is called Partial Transmit Sequence Technique.

III. Literature Review

Arunjeeva, L.; Arunmozhi, S. in March 2012, A novel complexity PAPR reduction scheme for SFBC MIMO-OFDM systems is proposed. The input string is multiplied by a set of phase rotation vectors respectively and then each resulting sequence is decomposed into several sub-sequences based on the linear property of SFBC. After having computing the inverse fast Fourier transform (IFFT) to convert each frequency-domain sub-sequence into a time-domain signal, as the equivalent SFBC encoding operations in the time domain for generating candidate signal sets have been performed, where one with the lowest PAPR is selected for transmission. With the proposed method, a large number of candidate signal sets by computing only a few IFFTs can be generated. The proposed one achieves similar PAPR reduction performance with much lower computational complexity.

Prema, G.; Amrutha, E. in July 2011, propose a closed loop multiple-input multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) transmit preprocessing system, where as the channel coding method referred as pilot symbol assisted rateless coding (PSAR) is used mitigate the effects of fading and wavelet based OFDM (WOFDM) is used to reduce PAPR. In the author’s proposed scheme wavelet is used in the place of FFT. Their coding approach for mitigation of fading and reduction of peak-to average power ratio combines the error correction capability of the channel encoder and achieves peak-to-average power ratio reduction in the OFDM method. The performance of given system is measured with the help of three parameters, bit error rate (BER), latency and complementary cumulative distribution function (CCDF) for PAPR The proposed system achieves about 3 dB improvement in PAPR over the traditional OFDM.

Umeda, S. ; Suyama, S. ; Suzuki, H. ; Fukawa, K in May 2010, linear precoding by block diagonalization (BD) for multiuser (MU) MIMO-OFDM systems proposed. BD transmission selected mapping (BD-SLM) that can reduce PAPR while maintaining the BD effect. Block Diagonalization - Select Mapping performs the phase shift to modulation signals of all users before the linear precoding. BD-SLM can drastically reduces PAPR in 16 × 4 MIMO-OFDM with four users.

Sen-Hung Wang; Chih-Peng Li in Nov. 2009, Authors demonstrates that a low-complexity PAPR reduction scheme is proposed for SFBC MIMO-OFDM systems, requiring only one IFFT. The proposed method exploits the time-domain signal properties of SFBC MIMO-OFDM systems to achieve low-complexity architecture for candidate signal generation.

Malathi, P.; Vanathi, P. T. investigated in May 2008, In this research work authors studied and modified Interleaving PAPR reduction technique is proposed. The given method for PAPR reduction gives an improvement over the existing technique at a cost of negligible decrease in the data rate.

Authors Rihawi, B.; Louet, Y.; Zabre, S. describe in Sept. 2007, In this work they investigated the formulation of the reduction of the PAPR problem as second order cone programming problem (SOCP) [1] to MIMO- OFDM. The given PAPR reduction method is originally based on a particular case of tone reservation (TR) approach which uses the unused carriers of standards. Applied approach does not degrade the bit-error-rate (BER) or the data rate and no side information is required. Implemented results are given for a MIMO-OFDM system with 2 antennas and 256 carriers as in IEEE 802.16 standard WiMAX .

IV. Problem Definition

Being a multicarrier modulation scheme, OFDM brings all key profit of a multicarrier scheme but unlike single carrier modulation schemes, it suffers from the problem of ICI. Explore the existing ICI cancellation schemes and perform a comparison of CIR and BER performances. The PAPR is an important parameter that must be taken into consideration while designing an ICI cancellation scheme for the OFDM system of practical applications use. Therefore, investigation of PAPR performance of OFDM systems utilizing ICI cancellation schemes is also considered as another area to be explored in this research paper. Final aim of this review paper is to suggest a joint scheme for simultaneous PAPR reduction in OFDM systems.

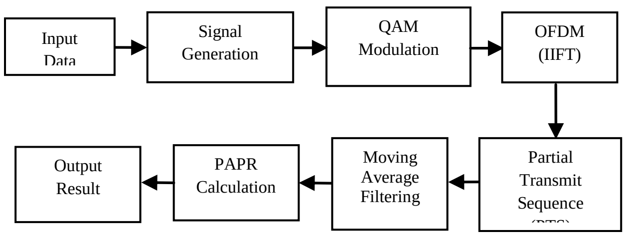

Fig. 2 Shows the block diagram of proposed methodology

V. Proposed Methodology

In our proposed methodology as the High PAPR is the major issue in the implementation of an OFDM system. The research paper aims to explore and arriving at efficient, low complexity schemes for PAPR reduction in OFDM based systems (with and without ICI cancellation) of practical use. In this work the high PAPR of an OFDM signal. We begin by exploring the existing PAPR reduction techniques by filtering method in this we use the Moving Average Filter and to find out their advantages and major limitations for implementing a practical OFDM system. Investigation of efficient PAPR reduction schemes for an OFDM system is thus considered as one of the problem areas explored. In the given figure 2 we presented our proposed methodology in graphical form.

VI. Conclusion

Till yet numerous researchers have adopt various research methodologies for ruction in PAPR as it is the consequence of MIMO OFDM technique. This paper presented a review on PAPR reduction techniques in MIMO OFDM transmission some methods avoid the use of any extra inverse fast Fourier transformations (IFFTs) as was done in PAPR reduction by ordinary PTS technique but instead is based on a proper selection of the different subcarriers and sub-blocks. The performance of the modified system using with proposed filtering technique which can be an effective scheme to achieve a better tradeoff between PAPR reduction and computational complexity.

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